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MEXICAN SPOTTED OWL HABITAT CHARACTERISTICS IN ZION NATIONAL PARK

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ABSTRACT.—We studied Mexican spotted owl (*Strix occidentalis lucida*) distribution, density, and habitat characteristics in Zion National Park from 1989–1991. We found 28 owls (12 pairs and 4 single males) at 16 different locations throughout the park. Estimated crude density ranged from 0.018–0.042 owls/km^2 while estimated ecological density ranged from 0.216–0.738 owls/km^2 over 3 years. Owls were associated with narrow canyons that usually contained a water source. Spotted owls used canyons that had greater absolute humidity and more vegetation strata than canyons selected at random. The geomorphology of these canyons may provide conditions compensatory to the complex forest structure associated with the owl elsewhere within its range by providing cool roosts and nest sites.

KEY WORDS: *density; habitat; Mexican spotted owl; microclimate;* Strix occidentalis lucida; *Zion National Park.*

Caracteríticas del hábitat de *Strix occidentalis lucida* en el Parque Nacional Zion

RESUMEN.—Entre 1989 y 1991, estudiamos la distribución, densidad y características del hábitat de *Strix occidentalis lucida* en el Parque Nacional Zion. Detectamos 28 individuos (12 parejas y cuatro machos), en 16 lugares diferentes del Parque. La densidad cruda estimada se encontró en el rango de 0.018–0.042 búhos/km^2, mientras que la densidad ecológica estimada se encontró en un rango de 0.216–0.738 búhos/km^2, en un período de tres años. Los búhos estaban asociados a estrechos cañones y que usualmente contenían agua. *Strix occidentalis lucida* usaban cañones que presentaban una gran humedad absoluta y más estratos vegetacionales que cañones seleccionados al azar. La geomorfología de estos cañones puede proporcionar condiciones compensatorias para la compleja estructura boscosa asociada con este búho en su rango de distribución, al proveer sitios de descanso fríos y de nidificación.
[Traducción de Ivan Lazo]

The Mexican spotted owl (*Strix occidentalis lucida*) occupies a broad geographic area in North America, but does not occur uniformly throughout its range (Gutiérrez et al. 1995). It occurs from the four corners states south to Michoacan, Mexico and reaches the northwestern limit of its range in southern Utah where the habitat is naturally fragmented. Disjunct canyon systems on the Colorado Plateau contain steep-walled canyons with little or no vegetation that provide unique habitat for spotted owls (e.g., Kertell 1977). This habitat is in stark contrast to forested canyon areas used by owls throughout the southwestern United States.

Spotted owls were reported from southern Utah as early as 1928 (Hayward et al. 1976). Prior to 1989, they were recorded in Glen Canyon National Recreation Area, Bookcliff Range, and Zion National Park (Behle 1960, 1981, Kertell 1977). Zion National Park contained the majority of historical locations (Kertell 1977). Yet no habitat assessment was available for the canyon habitats of the Colorado Plateau geographic province at the time the Mexican spotted owl was listed as a threatened subspecies (USDI 1993). Therefore, we investigated the distribution, density, and habitat characteristics of Mexican spotted owls in this unique canyon habitat.

STUDY AREA

Our study area was Zion National Park (59,353 ha) in southwestern Utah (National Park Service 1987). The climate was characterized by hot, dry summers and mild winters (Krell 1988). Temperatures ranged from −12–40°C and annual precipitation ranged from 30–50 cm (National Park Service 1987). Elevations ranged from 1,109–2,660 m (Brereton and Dunaway 1988). The Park was dominated by sheer cliffs of Navajo sandstone, slickrock terraces, and hanging canyons (e.g., a side canyon whose mouth lies above the floor of the main canyon) The terrain was extremely rugged with minimal access provided by roads and trails.

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Four vegetation communities dominated the Park: ponderosa pine (*Pinus ponderosa*), oak (*Quercus* spp.), sagebrush/pinyon-juniper (*Artemisia* spp./*P. monophylla-Juniperus* spp.), and riparian (National Park Service 1987). The ponderosa pine community was characterized by ponderosa pine, Douglas-fir (*Pseudotsuga menziesii*), and white fir (*Abies concolor*); the oak community consisted of Gambel oak (*Q. gambelli*) of a low-growing brushy stature, and scrub oak (*Q. turbinella*); the sagebrush/pinyon-juniper community was primarily sagebrush, pinyon pine, Utah juniper (*J. osteosperma*), and cacti (*Opuntia* spp.); riparian zones included species such as cottonwood (*Populus fremontii*), willow (*Salix* spp.), boxelder (*Acer negundo*), ash (*Fraxinus* spp.), and big-toothed maple (*A. grandidentatum*). Within the canyon riparian zones were "stringers" (vegetation arranged in long, thin strips) of ponderosa pine, white fir and Douglas-fir.

METHODS

During 1989–1991, we located owls using standard survey techniques (Forsman 1983, Franklin et al. 1990) with some modifications necessary to compensate for the rugged terrain (Rinkevich 1991). Modifications included calling from prominent ridge and mesa tops overlooking a canyon (e.g., point surveys) for 10–15 min at the top of each hour and then listening for the remainder of the hour during 3–5 hr night time periods. We also used a 45.7 cm diameter parabolic dish with headphones (Geleco Electronics Ltd., Ontario) to listen for owls calling in inaccessible canyons. We considered an owl location as a visual sighting of at least one adult spotted owl or a minimum of two auditory detections in the same canyon in the same year.

We surveyed the Park for owls using a stratified, random sampling scheme, using canyon and plateau areas as strata. These two areas were surveyed in proportion to their total area during 1989–90. In 1991, we surveyed as many canyons and forested areas as possible within the Park and resurveyed all canyons that were sampled in previous years.

We estimated crude density for each year by dividing the number of owls found in Zion Park by the size of the Park (Franklin et al. 1990). We also calculated ecological density by dividing the number of owls by the amount of suitable habitat (Franklin et al. 1990). We estimated suitable spotted owl habitat from the area of (1) canyons in which owls were detected during our surveys, (2) canyons that had been used by owls prior to our study (e.g., areas within the Park that had a previous record of spotted owls), and (3) canyons that shared similar characteristics to those in which we found owls. Because we intensively surveyed the Park for 3 yr, we were confident that our estimate of suitable habitat was reasonable.

We compared habitat characteristics of canyons where owls were found (owl canyons) with randomly-selected canyons which we surveyed, but in which we did not find owls (random canyons). We did not compare owl canyons to plateau areas because we did not find owls in plateau areas. Since some random locations could potentially harbor owls, this was a conservative test of the differences in habitat characteristics between used and available habitat.

Habitat sampling within owl canyons was accomplished in three ways. First, we centered a sample plot directly below the observed roost position of an owl (Solis 1983) When owls were found roosting on cliffs, sample plots were placed directly below the owl as close to the cliff as possible. Thus, transect lines often were parallel to the canyon wall. Second, we measured habitat throughout the canyon using a stratified, random sampling scheme when we found an owl but were unable to directly observe the bird (see below). Third, we sampled habitat using a stratified, random sampling scheme in canyons where owls historically occurred. Because no known major habitat or geologic changes occurred in previously occupied habitat, we assumed that the absence of owls from these historic sites was a function of owl demography (e.g., LaHaye et al. 1994) rather than due to changes in habitat.

We used the same stratified, random sampling scheme to measure habitat characteristics within both random and owl canyons. We first proportionately allocated the number of sample plots according to canyon size (e.g., more plots were measured in longer canyons). Then, we randomly selected sample plots throughout these canyons (Rinkevich 1991). Since longer canyons contained more plots, we averaged all plots within a canyon to obtain a single mean value for each canyon. The mean values of random plots were compared to the mean values of plots within owl canyons.

We measured 43 habitat characteristics within owl and random canyons (see Rinkevich 1991 for a complete list). Of the 43 characteristics, we measured five geomorphic (e.g., canyon width, length), two microclimatic (e.g., temperature and humidity), and 35 vegetation (e.g., tree height, basal area, strata layer) variables. Vegetation sampling followed Bias and Gutiérrez (1992). We used a variable circular plot method with a 20 basal-area factor wedge prism to define sample trees (Mueller-Dombois and Ellenberg 1974, Dilworth 1981). Geomorphic features were measured using a tape measure, pacing with a measured stride, or estimated from topographic maps Presence or absence of surface water was recorded. Ambient air temperature and percent relative humidity also were measured at each plot center. Relative humidity was measured using a sling psychrometer and later converted into absolute humidity (Ruskin 1965). Absolute humidity could then be analyzed independent of temperature. We assessed differences in habitat characteristics between owl and random canyons using Mann-Whitney *U* tests because the data were not normally distributed.

RESULTS

Density. We surveyed approximately 75% of Zion National Park within which we found 28 spotted owls (12 pairs and 4 single males) at 16 locations during 1989–91. Fourteen owl locations were in the Park and 2 were located on Bureau of Land Management (BLM) Wilderness Study Areas (WSAs) adjacent to Park boundaries. Because these latter two sites were within meters of the Park boundary they were included in density estimates. We detected 3 pairs and 3 single male owls at six

Table 1. Characteristics of canyons used by Mexican spotted owls and randomly sampled canyons in Zion National Park, Utah.

VARIABLE	OWL CANYONS MEAN (SD) (N = 13)	RANDOM CANYONS MEAN (SD) (N = 17)	MANN-WHITNEY U VALUE (P)
Absolute humidity[1]	9.41 (1.43)	6.51 (1.92)	24.0 (0.000)
Vegetation strata[2]	2.79 (0.31)	2.29 (0.41)	47.5 (0.007)
Percent canopy closure	0.43 (0.14)	0.39 (0.30)	99.0 (0.630)
Max. shrub height[3]	2.25 (35.80)	2.15 (29.53)	98.0 (0.601)
Min. shrub height[4]	0.35 (9.87)	0.36 (9.32)	113.5 (0.899)
Mature tree BA[5]	9.09 (12.65)	16.53 (26.44)	118.0 (0.716)
Medium tree BA[6]	13.17 (12.56)	8.34 (10.99)	83.0 (0.226)
Total live BA[7]	23.23 (21.47)	23.73 (24.93)	107.5 (0.899)
Snag BA[8]	0.38 (1.39)	0.69 (1.96)	115.5 (0.688)
Large woody debris[9]	0.63 (0.98)	0.59 (0.86)	104.0 (0.768)
Small woody debris[10]	0.54 (0.76)	0.69 (1.34)	112.0 (0.95)
Temperature (°C)	21.6 (8.49)	20.0 (11.94)	93.0 (0.46)
Canyon width[11]	85.13 (52.97)	117.69 (67.70)	137.5 (0.258)
Ledge height[12]	21.93 (31.20)	21.27 (44.59)	87.5 (0.296)
Bench height[13]	352.6 (371.03)	279.80 (376.08)	94.0 (0.490)

[1] Absolute humidity (gm/cm^3 of water).
[2] Number of vegetation layers (canopy, shrub, and herb) counted at each plot.
[3] Maximum shrub height (m) of tallest shrub in plot.
[4] Minimum shrub height (m) of smallest shrub in plot.
[5] Basal area of mature size trees (m^2/ha) (dbh from 52.5 to 89.8 cm).
[6] Basal area of medium trees (m^2/ha) (dbh from 27.5 to 52.4 cm).
[7] Total basal area of all live trees in plot (m^2/ha).
[8] Total basal area of all snags in plot (m^2/ha).
[9] Percent of ground covered by large woody debris (>30.0 cm in diameter at large end).
[10] Percent of ground covered by small woody debris (>2.5 to 30.0 cm in diameter at small end).
[11] Canyon width (m) at plot center using tape measure, pacing, or estimating from map.
[12] Height (m) to nearest ledge from canyon floor visually estimated.
[13] Height (m) to first bench from canyon floor (measured visually or from topographic map).

locations, 7 pairs and 2 single males at 9 locations, and 12 pairs and 4 single males at 16 locations in 1989, 1990, and 1991, respectively. Estimated crude density ranged from 0.02 owls/km^2 in 1989 to 0.04 owls/km^2 in 1991 with a mean of 0.03 owls/km^2 (95% CI = 0.018–0.042) for the 3 yr sampling period. Ecological density ranged from 0.26 owls/km^2 in 1989 to 0.71 owls/km^2 in 1991 with a mean of 0.48 (95% CI = 0.216–0.738).

Habitat. All spotted owls were found in narrow, steep-walled canyons (Table 1). No owls were located on plateaus or mesas, although some owls flew onto canyon rims in response to our calling. Elevations of owl canyons ranged from 1,277–2,000 m. Owls used trees, cliffs or rock ledges as roosts in these canyons. Of the 16 canyons in which owls were found, 8 (50%) had perennial streams, 6 (37.5%) had ephemeral water sources, and 2 (12.5%) were inaccessible and, thus, availability of water was unknown. Of the 17 random canyons in which we did not find owls, 2 (11.5%) had perennial streams, 3 (17.5%) had ephemeral water sources, and 12 (71%) had no water present.

Of the 16 owl canyons, 2 canyons were inaccessible and 3 were found late in the study so no habitat data were collected for them. The remaining 11 owl canyons plus 2 historical canyons were used in our analysis. We sampled 54 habitat plots in the 13 canyons. We sampled 17 random canyons (44 habitat plots) for comparative purposes.

Owl canyons were very narrow and deep and contained limited but structurally diverse vegetation (Table 1). Random canyons were similar to owl canyons in most respects, but there were more vegetation strata in owl canyons than in random canyons. In addition, the combination of more free water and more vegetation strata in owl can-

yons may have contributed to the higher absolute humidity measured in the owl canyons.

DISCUSSION

Density. Our estimated crude densities of spotted owls in Zion National Park were lower than any published record (Franklin et al. 1990, Gutiérrez and Pritchard 1990, Bias and Gutiérrez 1992) for spotted owl populations. We found more owls in each year of the study primarily because of an increase in sampling efficiency rather than because of a true demographic change (e.g., annual increases were the result of sampling new areas). Thus, with greater sampling effort we would expect more owls to be found in Zion Park.

On the other hand, our estimates of ecological density were similar to density estimates for other owl populations. This suggested that the number of owls in Zion National Park may be related more to the availability of specific canyon habitats rather than to demographic processes per se. However, the lack of striking habitat differences between owl and random canyons suggests that there may be habitat at Zion that is currently unoccupied. While our sample population was small, it represented approximately 40% of the known owls within southern Utah.

Habitat. Spotted owls have been considered dependent on forests with complex structure (Forsman et al. 1984, Chávez-León 1989, Call 1990, Bias and Gutiérrez 1992, Verner et al. 1992, Gutiérrez et al. 1995). Very little typical spotted owl habitat occurs on the Colorado Plateau, and almost none in Zion National Park. However, the geomorphologic relief apparently provides suitable habitat for spotted owls possibly by modifying microclimate and providing habitat structure. Owl habitat within canyons elsewhere in southern Utah ranges from rocky canyons containing patchy vegetation to narrow canyons containing little or no vegetation (pers. obs.).

Most of the owls we found were located in inaccessible, hanging canyons or steep-walled, narrow canyons and not in broad canyons with extensive sun exposure. Kertell (1977) also reported spotted owls associated with this type of habitat in Zion Park. The association of spotted owls with steep canyons has been reported from New Mexico (Johnson and Johnson 1985, Skaggs and Raitt 1988, Seamans and Gutiérrez 1995) and Arizona (Ganey and Balda 1989). However, the geomorphic relief within these areas did not approach that of Zion (pers. obs.).

Although Mexican spotted owls use rocky canyon habitat throughout their range it represents a relatively small proportion of spotted owl habitat in the southwest (USDI 1993, 1995). This suggests that only a limited subset of canyons in the subspecies' range contain the characteristics that provide suitable owl habitat.

In contiguous forests, spotted owls often have overlapping home ranges (Solis 1983, Forsman et al. 1984). The isolated nature of the deeply incised and extremely narrow canyons in the Park suggests that many owls in Zion have nonoverlapping home ranges because they are separated structurally and acoustically from adjacent canyons.

Mexican spotted owls appear to use canyon habitat because the geological and vegetation features produce distinctive environmental conditions important to spotted owls. Spotted owls respond to warmer temperatures by seeking cooler microclimates for roosting (Barrows and Barrows 1978, Solis 1983, Forsman et al. 1984). They have a narrow thermal neutral zone and experience heat stress at relatively low temperatures (Ganey et al. 1993). Thus, selection of cool, multi-layered forests in warm climates may be partly a response to physiological stress. It appears that the narrow canyons of Zion also modify local temperatures and humidity, particularly if water is available (see also Forsman 1976, Barrows 1981). In addition, the microclimate in these canyons may allow the development of forests with more complex structure, which are associated with spotted owls throughout most of their range. The more developed vegetation in owl canyons may also be advantageous to the owls' small mammal prey.

It appears that the geomorphology of the canyons provides roosting and nest sites for owls, modifies microclimate favorably, and allows more structurally diverse vegetation to develop. The vegetation in turn provides roost sites and possibly more habitat and food for the owls' prey. In these ways the unique features of these rugged canyons facilitate occupation by owls in an otherwise inhospitable landscape.

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